

TRANSPORTATION RESEARCH DIGEST

March 2010

ARIZONA TRANSPORTATION INSTITUTE

e-mail jsemmens@cox.net

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MARCH 2010

TO: TRANSPORTATION PROFESSIONALS, MANAGERS, & POLICY MAKERS

FROM: ARIZONA TRANSPORTATION INSTITUTE

The volume of information on transportation issues, policies, technologies, and related topics is huge. Not even the most well-read professional can keep up with everything that might be useful to know. The *Transportation Research Digest* series is designed to expedite the transmission of information by condensing and summarizing significant documents. Busy professionals or managers may quickly obtain the gist of new developments and determine whether they need to see the full document.

The *Transportation Research Digest* is not meant to present definitive resolutions of scientific or policy controversies, but contributions to the pursuit of knowledge and the debate of issues. The intent is to be comprehensive rather than conclusive on the multitude of issues and topics of concern to those working in the field of transportation. Readers are encouraged to obtain the original document summarized in the *Transportation Research Digest* and subject the content to their own judgment.

Transportation professionals who would like to recommend documents to be summarized or submit summaries to be considered for inclusion in this publication are invited to do so. To recommend a document please send a copy (or information indicating how a copy can be obtained) of the research report to be summarized. To be considered, the report must meet the following requirements: (1) it is transportation related, (2) it is no more than two years old, (3) there is enough information in the report to warrant a two page summary. To write a summary, insure that the document being summarized meets the above requirements. The summary should be submitted in an electronic format. This summary should be in the 500 to 800 word range and may include tables and/or simple graphics—all of which must fit within the *Transportation Research Digest's* two-page format. Submissions are subject to editing for clarity and length. We do not guarantee that all submissions will be published.

If you would like to obtain the full report upon which a *Transportation Research Digest* summary is based you have several options. Check your local university library. You may want to contact the publisher using the contact information appearing in the *Transportation Research Digest*. Some of the documents are free for the asking. Others can be purchased.

There is a database listing of all the previously published *Transportation Research Digests* that we have on file (back to 1984). Copies of the list or of portions of the list selected by topic or mode can be provided on request. You may also access the database via the internet at

Transportation Research Digests from December 1995 to November 2003 are available on request.

A “Topic” code in the Table of Contents will help readers more quickly identify items of interest. The topic codes are explained in the table below.

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AIRP	Airports	PRIV	Privatization
AVIA	Aviation	RAIL	Railroads
BIKE	Bicycles	RDS	Roadside
CON	Construction	ROW	Right-of-Way
ECON	Economics	SAFE	Safety
ENV	Environment	STR	Structures
FIN	Finance	TECH	Technology
INOV	Innovations	TOLL	Toll Roads
MAIN	Maintenance	TRAN	Transit
MISC	Miscellaneous	TRF	Traffic
MVD	Motor Vehicle Dept	TRK	Trucking
PAVE	Pavement	VEH	Vehicles

Requests or inquiries may be made via e-mail (jsemmens@cox.net).

Thank you.

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Evaluation of Ways and Procedures to Reduce Construction Cost and Increase Competition by Ivan Damnjanovic, Stuart Anderson, Andrew Wimsatt, Kenneth F. Reinschmidt, and Devanshu Pandit, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <http://tti.tamu.edu/documents/0-6011-1.pdf>) (Jan 2009)

Highlights

- ❑ A confluence of a number of factors is contributing to the observed trends in cost of construction including competition, contract requirements, and other factors.
- ❑ This research identified 56 methods that impact cost increase factors.

The problem of increased construction costs and reduced purchasing power is facing many state transportation agencies. While this problem is not endemic only to the transportation sector, transportation agencies are among the agencies that are the most affected. In fact, the deficit in short-term cash flow has already affected many projects. As a result, projects are delayed and programs are reduced. The purpose of this research is to identify factors affecting increases in highway construction costs and propose methods that can reduce or contain these costs.

The goal of this research report is to present a set of guidelines that can assist TxDOT in an attempt to reduce contracting costs and control cost increases. More specifically, the objectives pertaining to this research goal are:

1. Identify factors that affect increases in costs of bid items and identify methods and strategies that can help reduce the costs.
2. Develop recommendations that could result in cost reduction and develop more comprehensive guidelines on how to modify

projects to reduce initial construction costs while maintaining equal or better performance.

3. Assess how TxDOT can improve its project development and contracting procedures or processes to increase competition.

The research was based on four sequential steps. First, a survey of the experience TxDOT and other DOTs with increases in construction costs and methods for cost reduction and containment was conducted. This task was achieved through an extensive literature review. The literature review was followed by a series of fact-finding workshops where TxDOT and other DOT engineers participated in brainstorming sessions. The purpose of the brainstorming sessions was to identify factors affecting cost increases and generate ideas to how to reduce them. The active involvement of TxDOT engineers resulted in a comprehensive list of methods that have potential to control construction costs. Contractors' feedback was also obtained on the issue of method applicability and is included in this report. The Delphi process was used to rank the cost reduction methods and to obtain feedback on the effect of these methods on performance measures. The Delphi study resulted in a consensus among the participating experts regarding the effectiveness of the methods. Finally, similar methods were combined and then classified based on their

application: at the program vs. the project level. The data sheet for each method developed as an end result will provide engineers the guidelines for use and implementation of individual methods based on project stage and project characteristics.

A key finding of this study is that the rise in the cost of crude oil is not the sole factor contributing to the increase in cost of construction. In fact, a confluence of a number of factors is contributing to the observed trends in cost of construction including competition, contract requirements, and other factors discussed in this report. Fact-finding workshops revealed that these factors can be both internal and external. While TxDOT can try to eliminate some of the internal factors, eliminating external factors would be a difficult if not impossible task. The result from the Delphi study indicates that the cost reduction methods considered in this study can both address the internal and hedge negative effects of external factors. It is important to note that the methods applied in earlier phases of project development are perceived to have higher impact than those applied at the later stages.

This research identified 56 methods that impact cost increase factors; some of these methods have program-wide application and the rest have project-specific application. Such classification of methods is useful for implementation. The program-wide applicable methods need some decision-making and

policy-level changes and impact a wider number of projects. The project-specific methods are effective in addressing specific issues known to exist in the project development process.

The study makes the following recommendations to TxDOT:

1. While this research effort has identified a total of 56 cost reduction methods, only 35 methods are applicable on a project-based level. Out of 56 methods, 21 methods have applicability at the program level. TxDOT management should consider making arrangements for implementing these program-wide methods. In such settings, TxDOT procedures should be flexible enough to adopt recommended methods.

2. Since the methods employed at the early stages of project development yield better cost reduction results, management should consider pursuing implementation of methods in planning and programming phase with more focus.

3. The methods which have adverse effects on other performance measures should be considered with caution. Further, since the results show only perceived performance, engineers should exercise their best judgment in consideration of the methods. The information sheets developed to describe the methods should be a starting point in evaluating their applicability.

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Subbase and Subgrade Performance Investigation for Concrete Pavement by Youn su Jung, Dan G. Zollinger, Moon Won, and Andrew J. Wimsatt, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <http://tti.tamu.edu/documents/0-6037-1.pdf>) (May 2009)

Highlights

- The objectives of the field investigation were to identify the factors associated with the erosion process.

The objectives of the field investigation were to identify the factors associated with the erosion process. To this end, sections of US 75, US 81/287, FM 364, IH 10, and IH 635 were sampled and investigated using a number of techniques including visual survey, nondestructive testing using FWD, and GPR as well as DCP testing and coring.

Generally, untreated flexible base has not performed well particularly over moisture sensitive subgrades while most CSB have performed well particularly when used with an AC interlayer due to high resistance to erosion.

Untreated aggregate base on US 75 in the Sherman area showed poor performance, possibly due to poor subgrade drainage and poor support. The modulus of the base in the patched area was about twice the base modulus of the unrepaired sections.

An AC base on a lime-treated subgrade on US 81/287 in Wise County has performed reasonably well except in areas where the subbase and subgrade was eroded. The bond condition between the PCC and AC base layer was generally good but erosion between the slab and the AC layer and between the AC layer and the lime-treated subgrade diminished the structural integrity of the pavement.

The cement stabilized oyster shell base on FM 364 in the Beaumont area showed erosion at the interface with the PCC near the joint but no erosion was noted away from the joint as indicated by the good contact between the concrete slab and the base.

Distressed areas on the frontage road along IH 10 in Beaumont consisted of severe map cracking, spalling, and pumping due to placement of a CRC pavement over a soft silty and sandy subgrade. Some patched areas had settled and experienced corner breaks due to low LTE and poor support. Most of the damage appeared to be due to a weak subgrade.

The key distress types of CRC pavement over CSB on IH 635 in the Dallas area were the condition of the full-depth patches and the widened longitudinal joints, although the overall condition of the pavement appeared to be very good. The patches in the pavement were mostly likely repairs of punchout distress that are possibly a result of erosion and loss of support immediately below the slab.

The induced shear stress along the interface between concrete slab and base layer plays a major role in the erosion process. As the stiffness of the joint or crack decreases, the slab shear stress increases under the applied loading generating fines along the slab-subbase interface which are susceptible to dislocation under pressurized water movement via pumping through joint or crack to the pavement

surface. Pumping results in a void under the slab and leads to a loss of joint stiffness.

The erosion of material beneath the slab is an important performance-related factor that needs to be addressed in the selection of base materials as part of the design process for concrete pavements. In this regard, general design factors such as concrete slab stiffness, traffic, environmental factors and strength and abrasion resistance (or shear strength) of the base and subgrade materials should be considered relative to erodibility. Moreover, drainage and layer frictional conditions should be considered in the design process in order to consider the full extent of erosion damage. As background, past and current methods (including models) relative to erosion were reviewed.

The presence of water, the erodibility of a subbase material, the rate of voiding, the amount of deflection, and the number of loads are factors that influence erosion but current design procedures scarcely address these factors. Many erosion tests were developed in the 1970s and 1980s using various testing devices but none of those tests have been interpretable relative to field performance. Erosion test methods were reviewed and evaluated relative to their utility to characterize subbase and subgrade materials for erosion resistance relative to performance.

A list of alternative subbase types and materials were assembled based on the evaluation of field performance and other functional factors. Accordingly, the experience

with the use of cement-treated base had been good and recyclable materials (recycled asphalt and recycled concrete) show promise economically. Testing of selected materials is currently underway and results to date are summarized as well as a new test procedure to evaluate erosion.

The effect of a stabilized layer in a rigid pavement system was characterized relative to bending and deflection behavior using the ISLAB 2000 program. The relationship between the modulus of subgrade reaction and the elastic modulus was reviewed. The effective k-value from equivalent deflection is different for load and curling slab behavior. The elastic moduli and dynamic k-values from the backcalculation of FWD and ELSYM5 are comparable; however, the interpretation of k-value from plate load testing is susceptible to edge boundary and frictional condition. Nonetheless, a methodology shows how to consistently and realistically characterize CSB layers with respect to a specific level of support.

Clearly, the advantage of a design framework is to relate the characteristics of the base to performance in terms of the base thickness, stiffness, coefficient of friction, and strength and better understanding the use of subbase materials in terms of their effect on pavement performance. The tools to advance pavement design to the next level with respect to subbase performance are readily available and can be assembled from the test results generated in this research program.

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e-mail jsemmens@cox.net

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Texturing of Concrete Pavements, NCHRP Report 634 by J. W. Hall, K. L. Smith & P. Littleton, Applied Research Associates, Inc., Vicksburg, MS (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_634.pdf) (2009)

Highlights

- This report presents a recommended process for determining the type of concrete pavement texture that should be used for a specific highway project.

PCC surface textures with the overall lowest noise levels include the longitudinal diamond-ground and longitudinal grooved textures, followed by longitudinal-tine and longitudinal-drag textures. High levels of friction can be achieved with ground, grooved, and tined textures, particularly if good-quality aggregate is used in the concrete mixture. Friction for longitudinal-drag textures can become inadequate if a deep texture (MTD > 0.8 mm [0.03 in.]) is not achieved at time of construction and/or polish-susceptible aggregate is used.

Although uniformly spaced transverse-tine textures can produce moderate levels of overall noise, they are highly prone to creating objectionable tones. Closer spacing (0.5 in. [12.7 mm] or less) and shallower grooves can help reduce pavement-tire whine and overall noise. Variably spaced transverse-tine and skewed transverse-tine textures can result in moderately low levels of overall noise and can significantly reduce or eliminate objectionable tonal spikes. High levels of friction can be achieved with all three of these textures, particularly if good-quality aggregate is used.

Although the EAC and shot-blast textures evaluated in this study showed relatively high overall noise and low-to

moderate friction, the number of sections included in the evaluation (1 of each) was insufficient for a proper determination of noise and friction characteristics. Additional research is needed to verify indications from other countries that low levels of noise and adequate levels of friction can be successfully achieved with these textures.

Asphalt surfaces tested in this study (thin HMA overlay and proprietary ultra-thin bonded wearing course) exhibited low to moderately low overall noise and moderately high levels of friction. Depending on the surfacing type and the hardness of the aggregate in the existing concrete surface, re-texturing via longitudinal diamond grinding or grooving can be more cost-effective than application of an asphalt surfacing.

Based on extensive friction/micro-texture testing and available concrete mixture information, the use of higher quality aggregates in the concrete mixture helps maintain the micro-texture qualities needed for friction.

Loss of concrete pavement macro-texture over time/traffic is greatest for diamond-ground textures (0.015 to 0.02 in. [0.4 to 0.5 mm]) and lowest for longitudinally grooved and dragged textures (0.002 to 0.003 in. [0.05 to 0.08 mm]). The geometric shape (i.e., narrow fins) of the diamond-ground texture results in more substantial loss than textures with no grooves (drag textures) or those that have well defined, widely spaced,

and structurally sound grooves (longitudinal-groove textures).

Considerable differences exist between texture depth measurements obtained using the CT Meter and the high-speed profiler. Although the difference in sampling rates of the two devices is probably a factor, the texture type and direction are more profound factors, with longitudinal textures creating greater measurement difficulties for the high-speed profiler.

PSD analysis of pavement surface texture indicated that near-field SI noise is generally related to the PSD texture parameters L4/L63, A1/A2, and PW.

Detailed efforts to model SI as a function of various texture parameters (not just PSD texture parameters) were somewhat successful; the best predictive model ($R^2 =$

0.77) yielded SI as a function of A1/A2, RMS, and texture direction. Correlation analyses further indicated that reducing higher wavelength texture and increasing lower wavelength texture (i.e., decreasing the L4/L63 or A1/A2 ratios, and reducing PW) results in reduced noise.

ANOVA and regression analysis of texture (excluding PSD texture parameters), friction, and noise measurement data collected on all test sections, combined with other pertinent available test section data (e.g., age/traffic data, climate data, and pavement data), indicated that near-field SI noise is influenced to a large extent by texture depth and by texture type and direction. Also, SI is increased as the number of traffic applications is increased and the number/frequency of joints is increased.

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Implementing Transportation Knowledge Networks, NCHRP Report 643 by Spy Pond Partners, University of Minnesota Center for Transportation Studies, and Sandy Tucker, Texas A&M (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_643.pdf) (2009)

Highlights

- This report has developed a business plan for implementing TKNs, and has begun the process of conducting the outreach necessary.
- The business plan for TKNs defines ten key products and services to be provided.
- An implementation plan is provided.

Today's transportation professionals are facing an enormous set of challenges as they work to sustain and improve the mobility that is essential to our economic well-being, way of life, and security. Addressing congestion, unacceptably high fatality rates, aging infrastructure, and environmental sustainability in the midst of a worldwide economic crisis will require rapid discovery and adoption of technologies, practices, and methods that work. In this context, a well-functioning infrastructure for sharing and accessing relevant and timely information about current research, best practices, and lessons learned will be a necessity.

In recent years, there has been growing interest across the transportation community to provide a stronger, more coordinated approach to information access and availability for transportation professionals. In 2006, the Transportation Research Board published Special Report 284: *Transportation Knowledge Networks: a Management Strategy for the 21st Century* (also referred to herein as the TRB Special Report 284 and SR 284). This report laid the foundation for the establishment of

Transportation Knowledge Networks or TKNs, which were defined as "decentralized, managed networks linking information providers to users wherever they are located." TRB Special Report 284 recommended development of a business plan for moving forward with their implementation.

This report has developed a business plan for implementing TKNs, and has begun the process of conducting the outreach necessary to ensure broad understanding of this plan and its potential benefits. There are three major institutional elements to establishing a sustainable and well-functioning network for information sharing in transportation:

- Regional TKNs, which are groups of transportation organizations (for example, state DOTs, MPOs, transit agencies, and engineering firms) that work together to share their information resources and collaborate on information access improvements.
- A national TKN Coordination Function, with responsibility for developing a national infrastructure for transportation information sharing and for leading and supporting TKN activities. The Research and Innovative Technology Administration (RITA) of the U.S.DOT was identified in TRB Special Report 284 as a logical home for this function.
- An Advisory Board with senior transportation community representation to provide strategic direction and ensure accountability.

The business plan for TKNs defines ten key products and services to be provided to transportation practitioners by the regional TKNs, with support from the national coordination function. One of the major products to be provided is a national transportation information portal that will serve as a focal point for transportation professionals seeking information. Several services are included in the plan to ensure that this portal is continually refreshed with timely and useful information. Taken as a whole, the ten products and services in the business plan are designed to achieve (1) a noticeable improvement in information access as perceived by transportation professionals, (2) substantial increases in information sharing among transportation information producers and providers leading to greater efficiencies, (3) preservation of valuable information resources that are at risk due to employee retirements and other factors, and (4) capacity building among transportation information professionals to enhance their effectiveness.

Implementation of the products and services in the business plan will require an estimated \$13.5 million annually. A source for this funding will need to be identified.

Outreach activities conducted under this project to communicate the contents of the

business plan included individual meetings with senior transportation agency representatives, a focus group with transportation planning practitioners, a briefing and follow-up survey of the AASHTO Standing Committee on Highways (SCOH), and presentations at conferences. A variety of outreach materials were prepared, including an overview flyer, testimonials from members of the transportation community, and narrated slide presentations. Outreach materials included descriptions of hypothetical scenarios for how transportation practitioners would use the transportation information portal to find materials that would help them respond to specific assignments in an efficient manner.

An implementation plan is provided that includes activities that can be pursued prior to availability of additional funds to support the TKN effort as well as a sequence of steps to be followed when and if funding is made available. Immediate activities include continuation of outreach and incremental implementation and tracking of pilot information-sharing initiatives. Some of these activities are already being carried out by the AASHTO Research Advisory Committee TKN Task Force, the National Transportation Library (NTL), members of current regional TKNs, and participants of the Transportation Library Connectivity Pooled Fund Study.

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e-mail jsemmens@cox.net

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Analysis Shows Amtrak Lost \$32 Per Passenger in 2008 in *SubsidyScope* (Pew Charitable Trusts, contact Jeremy Ratner at 202-552-2137; <http://subsidyscope.com/transportation/amtrak>) (Oct 2009)

Highlights

- Forty-one of Amtrak's 44 routes lost money in 2008 with losses ranging from nearly \$5 to \$462 per passenger.
- No passenger rail service in the world is profitable.

The line with the highest per passenger subsidy—the Sunset Limited, which runs from New Orleans to Los Angeles—carried almost 72,000 passengers last year. The California Zephyr, which runs from Chicago to San Francisco, had the second-highest per passenger subsidy of \$193 and carried nearly 353,000 passengers in 2008. Pew's analysis indicates that the average loss per passenger on all 44 of Amtrak's lines was \$32, about four times what the loss would be using Amtrak's figures: only \$8 per passenger. (Amtrak uses a different method for calculating route performance).

The Northeast Corridor has the highest passenger volume of any Amtrak route, carrying nearly 10.9 million people in 2008. The corridor's high-speed Acela Express made a profit of about \$41 per passenger. But the more heavily utilized Northeast Regional, with more than twice as many riders as the Acela, lost almost \$5 per passenger.

Subsidyscope calculated profits and losses per passenger to ascertain which routes cost Amtrak the most to operate. Our analysis is based on a 2005 Government Accountability Office (GAO) critique of Amtrak's accounting methods, which says the railroad should consider depreciation when calculating profitability. Other capital intensive industries,

such as commercial airlines, include depreciation and overhead when looking at route performance.

In October 2008, Congress passed legislation reauthorizing Amtrak for an average of \$1.5 billion a year for five years. The Passenger Rail Investment and Improvement Act requires that the railroad provide metrics for measuring all long-distance routes and find ways to improve the financial performance of those routes. Amtrak officials say they are considering options to make the Sunset Limited less costly.

Amtrak lost \$1.1 billion last year, but says that only \$236 million of this should be attributed to its core business lines, such as the Northeast Corridor. The remainder, it asserts, should be associated with ancillary businesses, depreciation and other direct costs, such as fuel and power, locomotive maintenance and call centers. Amtrak's ancillary businesses include contracted operator services to commuter trains around the country, such as the MARC in Maryland and Caltrain in California, many of which are buttressed through state and local funding sources. The ancillary businesses are actually a source of profit for Amtrak, bringing in \$93.7 million in 2008.

Subsidyscope took Amtrak's operating results as they appear in Amtrak management reports, which include depreciation and other overhead costs. The results were distributed evenly across all routes using 2008 ridership numbers; we divided Amtrak's overall operating loss by total ridership, arriving at \$24.29 per passenger in additional losses. This figure is on top of Amtrak's reported profit or

loss per route. See this page for details and our complete data set.

Subsidyscope also analyzed route performance based on passenger miles traveled. Using this approach—as opposed to a per passenger calculation—and including the same overhead and depreciation costs, we found that Amtrak routes lose an average of 11 cents per passenger mile more than the railroad reports. When examined this way, four, rather than three, Amtrak lines appear to make money. The Northeast Regional shows a loss of nearly \$5 when examined on a per passenger basis but a profit of 2 cents on a per passenger mile basis. Still, the line showed a substantially lower profit than the 13-cent-per-mile contribution Amtrak reported. The methodology and complete results for both calculations are presented here.

The differences between the two calculations performed by *Subsidyscope* show that route performance can be measured in different ways. Amtrak argues that it is not fair to include depreciation in assessing a route's

financial performance. Due to a series of sale-leaseback transactions involving the company's equipment in the 1990s, depreciation values have been distorted, the railroad says. An Amtrak official told *Subsidyscope* that ridership is the only factor that should be considered when calculating the profitability of any line.

The GAO, however, found that not including depreciation caused an understatement of reported expenses for core and ancillary business lines by 19 percent and 15 percent, respectively. The GAO said information about depreciation is critical to any financial assessment because Amtrak relies heavily on its rail cars and other capital.

In August 2009, the Congressional Budget Office considered the option of reducing Amtrak's federal subsidy by about \$200 million a year for five years. Amtrak officials and passenger rail advocates say this is impractical, noting that no passenger rail service in the world is profitable and arguing that Amtrak would cease to exist without the federal money.

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e-mail jsemmens@cox.net

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High-Speed Rail Is Not “Interstate 2.0” by Randal O’Toole (Cato Institute, 1000 Massachusetts Avenue, N.W., Washington D.C. 20001-5403; <http://www.cato.org/pubs/bp/bp113.pdf>; ph 202-842-0200) (September 9, 2009)

Highlights

- ❑ High-speed rail is ten times more costly per person-mile of travel than highways.
- ❑ There are more cost-effective ways to improve transportation and the environment.

When President Obama announced his vision for high-speed rail in the United States, the White House stated that the plan “mirrors that of President Eisenhower, the father of the Interstate Highway System, which revolutionized the way Americans traveled.” A former Federal Railroad Administration official called the plan “Interstate 2.0.”

Yet there are several crucial differences between high-speed rail and the Interstate Highway System. Most importantly, before Congress approved the legislation that created the Interstate Highway System in 1956, it had a good idea of how much the roads would cost, how the country would pay for them, and who they would serve. In contrast, neither President Obama nor the FRA have ever offered any estimates of how much their high-speed rail plan would cost, how it would be financed, or who would ride the trains.

A close look at the data reveal that high-speed rail would not be a revolution but more of a counterrevolution: a step backwards to a time when only the wealthy had mobility and when low- and middle-class people worked hard to keep the wealthy mobile. For the mobility and other benefits it would produce, high-speed rail would be many times more expensive than the interstates. And while the vast majority of Americans use the interstates,

use of high-speed rail would be confined to a few elites.

High-speed rail is a technology whose time has come—and gone. What might have been useful a century ago is today merely an anachronism that would cost taxpayers tens or hundreds of billions of dollars yet contribute little to American mobility or environmental quality.

The most ardent supporters of high-speed rail predict that the FRA plan would carry the average American less than 60 miles per year, and in most places outside of California the average would be even less. By comparison, the average American travels by automobile more than 15,000 miles per year. The environmental benefits of high-speed rail are similarly miniscule, and when added to the environmental costs of building high-speed rail lines the net result is certainly negative.

Given high costs and tiny benefits, the real impetus behind high-speed rail for some is the desire to change Americans’ lifestyles. High-speed rail is a part of the administration’s “livability agenda,” which involves increasing the share of families living in multi-family housing while discouraging new single-family homes, and increasing the share of travel on transit and intercity rail while discouraging driving. As Transportation Secretary Ray LaHood recently admitted, the purpose of this campaign is to “coerce people out of their cars.” History shows that such behavioral programs are costly and produce few environmental or social benefits.

Based on these findings, states should apply for their share of the \$8 billion in stimulus money solely for safety improvements to existing rail lines, such as better crossing gates. They should not plan to purchase new locomotives and railcars for passenger service that would be both expensive to operate and harmful to the environment. Nor should the Federal Railroad Administration commit the

federal government to funding expensive new high-speed lines such as the proposed lines in California or Florida.

The United States can do many things to improve transportation networks in cost-effective ways that save energy, reduce accidents, and cut toxic and greenhouse gas emissions. High-speed rail is not one of those things.

Interstate and High-Speed Rail Costs, Per Passenger Mile

	Capital Cost	Amortized Cost	Passenger Miles	Cost Per Passenger-Mile
	(\$billions)	(\$billions)	(billions)	(cents)
Interstate highways	\$425	\$33.9	1,034.4	3.2
Moderate-speed rail	\$27	\$2.1	12.7	27.3
High-speed rail	\$52	\$4.2	7.9	32.6

Note: The interstate highways are 10 times more cost-effective at moving people than high-speed rail.

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Analysis of Roadside Safety Devices for Use on Very High-Speed Roadways by Nauman M. Sheikh, Rubiat Ferdous, Roger P. Bligh, and Akram Y. Abu-Odeh, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <http://tti.tamu.edu/documents/0-6071-1.pdf>) (Sep 2009)

Recommended roadside safety hardware

- ❑ Modified Thrie-Beam Guardrail.
- ❑ Box Beam Guardrail
- ❑ Bridge Rail
- ❑ Slip base Sign Supports

TxDOT continues to plan for expansion of the state's transportation system. There is interest in using very high design speeds (above 80 mph) for some of these facilities to promote faster and more efficient travel within the state. The objective of this research is to develop roadside safety hardware suitable for use on very high-speed highways.

The project monitoring committee prioritized the order in which roadside safety hardware for very high-speed roadways should be developed.

Modified Thrie-Beam Guardrail

The modified thrie-beam guardrail is the result of improvements to the standard thrie-beam guardrail and was specifically designed as a high-containment system to reduce the rollover incidences for heavy vehicle impacts. The system incorporates deep offset blocks that are designed to reduce snagging interaction between the impacting vehicle and support posts, and help keep the thrie-beam rail vertically aligned during impact to reduce the probability of vehicle climb, vaulting, and/or instability.

Researchers observed in the high-speed simulations that the steel blockouts deformed

and collapsed as the vehicle progressed through the system. This collapse reduced the offset distance between the rail and posts and led to significant interaction between the front wheel assembly and the guardrail support posts. The front wheel assembly was observed to ride over the twisted and bent steel posts, which in turn imparted a vertical acceleration to the vehicle that helped it climb over the rail. Thus, although the rail was found to have sufficient structural capacity to accommodate the increased impact severity, the rail failed to contain the design pickup truck.

Box Beam Guardrail

The box beam guardrail system incorporates a strong tubular steel rail member supported on relatively weak steel posts. The strength of the tubular rail provides significant structural capacity beyond current design requirements, and the weak support posts eliminate the snagging concerns that exist for strong-post systems.

In the high-speed impact simulation, the pickup truck was redirected. However, the large lateral deflection of the system led to a long length of unsupported rail. The lack of vertical support allowed the tubular rail to drop in height when the lateral impact force diminished during the vehicle's attempt to exit the system. This behavior indicates a significant probability that the vehicle will override the system.

Bridge Rail

The project advisory committee expressed a strong desire to have a concrete bridge rail alternative available for use on very high-speed roadways. Advantages of concrete over metal beam and post systems include low installation cost and minimal maintenance and repair needs.

The low maintenance and repair quality of concrete barriers reduces exposure of maintenance/repair personnel and potential traffic conflicts associated with temporary lane closures, which is a significant concern for high-volume roads with very high-speeds.

The concrete bridge rail selected for evaluation for high-speed applications was the single-slope barrier. The single-slope barrier has one constant sloping traffic face that is 10.8 degrees from vertical. Previous testing has shown it to provide a reasonable compromise between vehicle stability concerns associated with safety-shaped profiles and occupant risk concerns associated with vertical concrete parapets.

The results of the high-speed impact simulations into the single-slope barrier indicate marginal to unacceptable performance. While it is predicted that the single slope barrier will contain and redirect the design pickup truck in a stable manner, the occupant risk numbers and occupant compartment deformation are expected to be close to the allowable limits of the MASH criteria. Although stable redirection of the design passenger car is also predicted, the lateral OIV is expected to be at or above the maximum acceptable recommended in MASH.

In a separate analysis, simulation results confirmed that a high-speed impact into the

New Jersey safety shape barrier is likely to result in high vehicle climb and roll, with a high probability of vehicle rollover when impacted by a small passenger car.

Sign Supports

The sign support system selected for high-speed performance evaluation was the slip-base. The slip-base has been used for decades to achieve acceptable breakaway performance for both small and large sign support systems. Upon impact with the support post, the upper foundation plate “slips” relative to the fixed lower foundation plate and the vehicle ideally travels under the rotating sign support structure with secondary contact.

The performance of the slip-base sign support systems was found to be satisfactory for passenger cars impacts at very high-speeds. The increased rotational velocity imparted to the support was offset by the greater speed of the vehicle. The vehicle passed beneath the sign support system without secondary contact with the roof or windshield.

However, the test matrix for breakaway supports under MASH has been revised to include a high-speed test with a pickup truck in addition to a small car. In an 85 mph head-on impact simulation with a pickup truck, the sign panel was predicted to impact the roof of the pickup with significant force. The severity of this secondary contact is expected to result in unacceptable occupant compartment deformation (i.e., > 4 inches of roof crush), leading to the conclusion that the standard 7-ft mounting height of the sign panel is not sufficient to accommodate the taller pickup truck at very high impact speeds.

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Performance Evaluation of Cable Median Barrier Systems in Texas by Scott A. Cooner, Yatin K. Rathod, Dean C. Alberson, Roger P. Bligh, Stephen E. Ranft and Dazhi Sun, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <http://tti.tamu.edu/documents/0-5609-1.pdf>) (Aug 2009)

Highlights

- From a perspective, a cable barrier is an attractive option compared to a concrete median barrier.
- Cable barriers are performing extremely well and have had very few cases of penetration.
- Cable barriers are eliminating 96% of cross-median crashes.

Conclusions

- From a capital cost and life-cycle cost perspective, cable barrier is an attractive option compared to concrete median barrier.
- Mow strips are a costly component of cable barrier system implementation; however, they provide excellent maintenance-related benefits and should continue to be required on new installations.
- There has been a lack of coordination between TxDOT and emergency responders during the project planning and maintenance phases of cable barrier system projects.
- Maintenance costs and personnel requirements for cable barrier systems can be substantial, and constrained budgets can cause consideration of barrier removal if safety is not adversely impacted.
- Barrier placement is an extremely important design consideration, with

safety and maintenance performance being significantly affected.

- Cable barriers are performing extremely well and have had very few cases of penetration unless there were non-standard impact conditions. The research team believes that the cable barriers are functioning according to their intended design and are restraining vehicles that impact them in fashions similar to NCHRP 350 crash testing guidelines.
- Cable barriers are making a significant contribution to the reduction of fatal and incapacitating injuries on state roadways, effectively eliminating 96 percent of these injury types caused by cross-median crashes.
- The GIS-based barrier inventory developed during this research is a good demonstration of the capability of this type of application for management of roadside safety devices such as cable median barrier systems.
- Due to problems experienced in Texas and other states, soil conditions should be considered as part of the project development process for cable barrier system installations.

Recommendations

- Continue to install cable barrier systems in medians that meet guidance criteria.

- Increase coordination with emergency service providers during the project planning and maintenance phases to ensure that their needs are considered, and where practical, implemented.
- Continue to closely-monitor the maintenance and repair activities of cable barrier systems throughout the state to gain an understanding of cost over a longer period of time.
- Consider implementation of a statewide maintenance contract for cable barrier maintenance and repair. The South Carolina DOT is a good example of this private contracting approach, with a \$2 million per year contract for almost 500 miles of cable barrier that requires repairs be completed within 96 hours following official notification.
- Cable barriers should be placed as far from the traveled way as possible while maintaining the proper operation and performance of the system. The more lateral offset afforded a driver, the better the opportunity for the driver to regain control of the vehicle in a traversable median and avoid a barrier impact.
- TxDOT should continue to perform annual updates of the safety evaluation to make sure the benefits of cable barrier systems are documented.
- Expand the development of the prototype GIS-based barrier inventory to include additional data and other types of roadside safety devices.
- Conduct further research to address the geotechnical issues identified during the in-service performance evaluation so that soil conditions can be appropriately addressed prior to installation of cable barrier systems.

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Transportation, Social and Economic Impacts of Light and Commuter Rail by Jeffrey C. Arndt, Curtis Morgan, John H. Overman, Terry L. Clower, Bernard L. Weinstein, and Michael Seman, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <http://tti.tamu.edu/documents/0-5652-1.pdf>) (Sep 2009)

Highlights

- ❑ Property values near light rail stations are boosted.
- ❑ Property values along the track, but not near the stations are depressed.
- ❑ An estimated \$127 million yearly in state and local tax revenue will potentially be raised by DART Rail TOD projects.
- ❑ The cost to build and operate the light rail system, net of passenger revenues, averages about \$150 million per year.

Fiscal impacts resulting from light rail transit deal primarily with the resulting effects of transit-oriented development taking place primarily at transit stops. The DART light rail system has been leveraged successfully for TOD opportunities resulting in significant fiscal impacts on the jurisdictions surrounding many DART transit stations. In 2007, a study was completed to measure these impacts. A several step process was used with the initial step consisting of data gathering. By using secondary sources such as newspapers, business and trade publications, websites, and personal communication with key informants, a matrix was constructed listing all projects that were either announced, under construction, or finished in conjunction with DART Rail TOD locations.

Accepting that the possibility existed for a project to be overlooked, the further step was taken of analyzing DART Rail TOD locations through visual means. By utilizing an

online mapping tool provided by the Greater Dallas Chamber of Commerce, aerial photographs of DART Rail TOD locations from 1997 to 2005 were examined. Any structures that appeared in the 2005 photos that were not apparent in the 1997 photos were then noted, checked against the existing matrix of projects, and if not accounted for, were then subject to direct field observation in order to further detail the project.

Once all structures were accounted for and documented, the next step consisted of deciding which projects “would have happened anyway.” This process examined each project for a direct tie to a DART Rail TOD location. In the case of a standalone, big box retail store such as Best Buy being built in proximity to a “kiss and ride” station, that project would be stricken from the matrix as not being a direct result of TOD. Conversely, a project like the W Hotel in the Victory Park development of downtown Dallas was assessed and found to have a partial link to the adjacent DART Rail TOD project. Discussion with a representative of the hotel found that the nearby transit station did aid in employee recruitment and retention, but had no impact on the guests or residents. In this instance, the value of the project was reduced to a third of what was published.

Once the matrix of TOD activity was completed with values assessed for each project (announced, in development, completed), the final step was to assess the taxable value of the properties. By using information provided by

county appraisal districts, assessments were made for the amount of tax revenue that would be generated by taxes related to real property as well as business personal. In addition, consideration was given to the amount of sales tax that would be generated by the retail aspects of the projects considered. This methodology yielded the following results.

- The total value for all current and projected TOD projects near DART Rail stations is estimated at \$4.9 billion.
- After considering projects that “may have happened anyway” and were not directly attributable to the presence of DART Rail, the figure was adjusted to \$4.26 billion.
- After further adjusting for tax exemptions and the value of public buildings, \$2.84 billion is the resulting tax base from which to make estimates.

Based on this figure, potential yearly property tax revenues include \$6.6 million for Dallas and Collin counties and \$16.8 million

for DART member cities. Area school districts may gain over \$46 million each year in new revenues. Community college districts in Dallas and Collin counties would benefit from \$2.3 million per year, while Parkland Hospital may benefit from \$6.7 million in new revenues yearly. When all retail components of the TOD projects were considered and analyzed using a standard fiscal planning model, \$660 million in annual taxable retail sales was projected. These sales will produce more than \$48 million in sales tax revenue for local municipalities and the State of Texas. In total, more than \$127 million yearly in state and local tax revenue will potentially be raised by DART Rail TOD projects. The cost to build and operate the light rail system, net of passenger revenues, averages about \$150 million per year. So, even though selected segments of the community gain, the aggregate economic impact for the entire community is negative. Consequently, the community, as a whole, would have been economically better off if DART had not ventured into light rail.

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Traffic Control Strategies For Congested Freeways And Work Zones by Geza Pesti, Poonam Wiles, Ruey Long (Kelvin) Cheu, Praprut Songchitruksa, Jeff Shelton, and Scott Cooner, Texas Transportation Institute, The Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; <http://tti.tamu.edu/documents/0-5326-2.pdf>) (Oct 2008)

Highlights

- The number of vehicle conflicts observed at both study sites decreased after the queue warning system was deployed and activated.
- Optimal results occurred when 20% of the vehicles were diverted from the freeway main lanes.

Condition-responsive traffic control strategies addressing the following three problem areas were identified and evaluated:

- end-of-queue warning,
- queue spillover at exit ramps, and
- work zones with lane closure.

Two queue warning systems, deployed on IH 610 and US 59 in Houston, Texas, were evaluated based on field observations. Strategies to tackle a ramp spillover problem at an exit ramp in El Paso, Texas, were evaluated based on traffic simulations. The Dynamic Merge work zone traffic control concept was evaluated using traffic simulations, and recommendations were developed for its potential use for various work zone types with different lane closure configurations. Findings of these evaluations are summarized below.

Queue Warning System Evaluation

The number of vehicle conflicts observed at both study sites decreased after the queue warning system was deployed and activated. At the study site on IH 610, the need for sudden braking to avoid rear-end collisions

was reduced by 7%, forced lane changes by 5%, and other erratic maneuvers by 3%. For the same type of vehicle conflicts the reductions at the study site on US 59 were less significant, between 2% and 3%.

The variance of speed was significantly reduced at both sites, indicating an improvement in the uniformity of speeds in the vehicle stream. The more uniform speed distribution resulted in reduced rear-end collision potential and safer traffic operations.

Safety evaluation of the queue warning system based on accident history requires a much longer time period than that available in this research project. No final conclusion may be drawn based on the limited amount of accident data that were available.

Mitigating Queue Spillover at Exit Ramps

Based on the simulation results it may be concluded that the optimal results (in terms of minimum queue spillback, minimum increase in density, minimum reduction in speed, and minimum acceleration, all at the freeway upstream of the Hawkins exit ramp) occurred when 20% of the vehicles were diverted from the freeway main lanes on to the alternative route.

The analysis of queue lengths at both exit ramps showed that the spillback at the Hawkins exit ramp is of a smaller magnitude with higher percentage of diversion. Despite the improvement on the freeway, queue length increased at the Hawkins intersection, causing

slower queue spillback dissipation at the exit ramp and on the frontage road. As for the McRae exit ramp, the increase in queue length is minimal and therefore there is no queue spillback onto the freeway.

The density upstream of the Hawkins exit ramp increased with queue growth from the exit ramp onto the right-most lane of the freeway. The density decreased when traffic was diverted to the alternative route (McRae exit ramp). The reduction in density is directly proportional to the diversion. As expected, the change in density is more significant in the right-most lane compared to other freeway lanes. The density upstream of the McRae exit ramp did not have significant variation with and without the diversions.

Speed and acceleration were the other two performance measures analyzed. Upstream of the Hawkins exit ramp, speed started to drop when the queue formed in the right-most lane of the freeway. The reduction in speed is the least significant when 20% diversion was simulated. Upstream of the McRae exit ramp, the different diversion percentages had almost no impact on speed for the entire simulation. As for acceleration, the average acceleration upstream of the Hawkins exit ramp decreased with increasing diversion. Our results also showed that upstream of the McRae off ramp

there is no noticeable change in the acceleration with and without the diversions.

Dynamic Merge Evaluation

It was envisioned that the Dynamic Merge would be field tested in a freeway work zone in Texas. However, an appropriate work zone site for field evaluation was not available within the timeframe of the research project. Therefore, the Dynamic Merge concept was evaluated based on traffic simulations. The objective of the simulation study was to determine the type of work zone configurations where the Dynamic Merge is expected to work well and provide benefits relative to the conventional work zone traffic control.

It was found that the Dynamic Merge would probably not work as intended in several of the lane closure configurations considered in this study. It is expected to work well only in three cases from the ten lane closure scenarios considered. Findings of the simulation studies and recommendations for using or not using the Dynamic Merge for certain lane closure scenarios were provided.

A Field Guide was developed to aid construction personnel and area engineers in using appropriate queue warning techniques and the dynamic merge control for congested freeways.